

SEMICONDUCTOR PHYSICS DEPARTMENT OF VILNIUS UNIVERSITY – EXPERTISE IN COMPLEX CHARGE TRANSPORT AND TRAPPING PHENOMENA

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Semiconductor Physics Department and Institute of Applied Research of Vilnius University have the long-standing experience based on the know-how expertise in charge transport characterization in different semiconducting materials, ranging from single crystals to organic semiconductors.

The Organic Solar Cell activities of our group are centred on the fundamental characterization of charge injection, generation, trapping, and transport properties as influenced by different types of material defects, depending on material and device engineering. The necessity of such investigations oriented at final practical needs is undisputable and is based on the state-of-the-art:

- Electrical properties of organic materials are strongly influenced by existing imperfections and defect traps, depending on the way of fabrication, synthesis route, doping, etc,
- Nevertheless, neither unique transport mechanism nor model is evident in organics, as the famous Baessler mobility expression does not highlight the complex inlying processes, including, e.g., carrier trapping by defects,
- Therefore, to foresee, model and control device characteristics the exhaustive analysis of defect properties and their effects on charge transport is necessary,
- Influence of the variation of carrier mobility and their density on the total device conductivity should be singled out,
- Defect spectroscopy is relatively rarely used to investigate an in depth-nature of existing defects, though without such understanding the purposeful device engineering is not possible.

A number of methods that are exclusively well suited for the investigation of organic materials and devices are available at our department, e.g., Thermally Stimulated Current and Depolarization Spectroscopy, Photoelectrical and Optical Spectroscopy from IR to UV, DLTS, IV characterization. A number of complementary mobility measurement methods cover range from 10^{-8} cm²/Vs to 100 000 cm²/Vs. All these techniques can be applied in the temperature range from 10 K up to 450 K, and the current sensitivity of the apparatus is 10^{-17} Amps. Other available photoelectrical methods can be tailored to suit the experimental needs. Application of complementary methods enables an exhaustive characterization of photoelectrical material and device properties under investigation.

Our group is actively involved in several running or recently finished international and national scientific programs, e.g., the FP6 projects MOLYCELL and OrgaPVNet, STALORGAPV project in the framework of PV ERANET, CERN RD-50 project and others. Number of formal or informal bilateral collaboration projects with the European and world institutions should also be mentioned (CEA, France; University of Angers, France; IMEC, Belgium; Imperial College London; FISE, Germany; University of Wellington, New Zealand; Tzing-Hua University, Taiwan; and others).

Some of our recent selected publications:

1. C. Sentein, L. Rocha, A. Apostoluk, P. Raimond, I. Duysens, I. Van Severen, T. Cleij, L. Lutsen, D. Vanderzande, V. Kažukauskas, M. Pranaitis, V. Čyras, Evidence of the improvement of photovoltaic efficiency by polar molecule orientation in a new semiconducting polymer. *Sol. Energ. Mat. Sol. C.* **91**, 1816 (2007).
2. V. Kažukauskas, V. Čyras, M. Pranaitis, A. Apostoluk, L. Rocha, L. Sicot, P. Raimond, C. Sentein. Influence of polar molecular chain orientation on optical and carrier transport properties of polymer blends. *Org. Electron.* **8**, 21 (2007).
3. V. Kažukauskas, M. Pranaitis, V. Čyras, L. Sicot, F. Kajzar. Negative mobility dependence on electric field in poly(3-alkylthiophenes) evidenced by the charge extraction by linearly increasing voltage method. *Thin Solid Films*, in Press (2008).
4. V. Kažukauskas, V. Čyras, M. Pranaitis, F. Kajzar, M. Glatthaar, A. Hinsch. Charge carrier trapping in organic solar cell structures P3HT:PCBM. *Mol. Cryst. Liq. Cryst.*, in Press (2008).